PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : **H04Q 7/34** | **A1**

(11) International Publication Number: **WO 00/30384**

(43) International Publication Date: 25 May 2000 (25.05.00)

(21) International Application Number: PCT/SE99/01746

(22) International Filing Date: 1 October 1999 (01.10.99)

(30) Priority Data:
9803916-7 17 November 1998 (17.11.98) SE

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventors: FRODIGH, Magnus; Risvägen 1 F, S-192 73 Sollentuna (SE). ALMGREN, Magnus; Viktoriavägen 1, S-191 43 Sollentuna (SE). JOHANSSON, Christer; Framnäsbacken 18, S-171 66 Solna (SE). HALVARSSON, Mats; Snövägen 161, S-976 33 Luleå (SE). KALLIN, Harald; Kruthornsvägen 40, S-192 53 Sollentuna (SE).

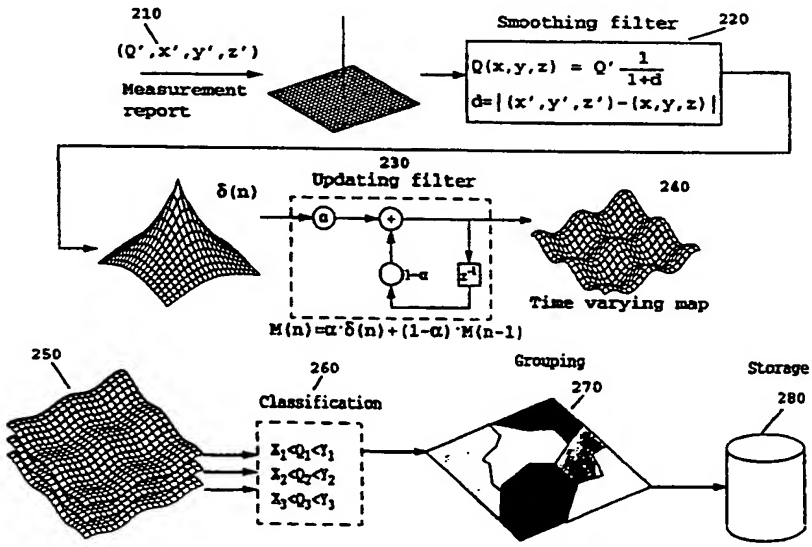
(74) Agent: ERICSSON RADIO SYSTEMS AB; Patent Support/Ericsson Research, S-164 80 Stockholm (SE).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

FP04-0067-00EP-NT
04.6.-9
SEARCH REPORT

(54) Title: METHOD AND ARRANGEMENT FOR MEASURING AND PREDICTING OF RADIO CONDITIONS IN A COMMUNICATIONS SYSTEM



BEST AVAILABLE COPY

(57) Abstract

In a mobile telecommunication system the transmission quality is dependent on a wide range of radio conditions. The method solves the problem associated with extracting a useful estimation of the radio environment of a mobile station in communication in order to predict how the radio conditions will change for the considered mobile station in the near future. A measurement report (210) is sent from the mobile station to its serving base station. The quality measured in the measurement report is filtered over the area by a smoothing filter (220), and then processed through an updating filter (230) resulting in a time varying map (240). Several maps are classified (260). Classified data are grouped (270) resulting in the final map, which is stored in a database (280). The final map may be used to enhance the performance of radio network algorithms.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

\SDOCID: <WO_____0030384A1_I_>

METHOD AND ARRANGEMENT FOR MEASURING AND PREDICTING OF RADIO CONDITIONS IN A COMMUNICATIONS SYSTEM

FIELD OF INVENTION

The present invention relates to a method and devices for wireless communication with a mobile station.

DESCRIPTION OF RELATED ART

In a mobile telecommunication system the transmission quality is dependent on a wide range of radio conditions. The radio conditions vary with the distance from the base station, atmospheric conditions, the topography around the considered mobile station etc. As the radio conditions are rapidly varying for the considered mobile station, the transmission quality may sometimes deteriorate in such an extent that the connection is lost. On the other hand, when the radio conditions are good, the transmission quality may be oversized resulting in unnecessary costs. However, the problem associated with extracting a useful estimation of the radio environment of a mobile station in communication in order to predict how the radio conditions will change in the near future for a considered mobile station remains unsolved.

Having no information on the location of the mobile station in communication it is very hard to predict how the radio conditions will change in a near future for a considered mobile station. The radio network algorithms for a radio communication system are usually designed to try to follow the changes of the radio conditions and react upon the changes in order to suitably adapt electric and other

characteristics when transmitting to a mobile station. However the radio environment of a mobile station is mostly changing very fast. For example, a small change in the position of a mobile station may result in a large change in received signal strength due to rapid fading. Therefore it is also mostly very difficult to accurately and rapidly enough follow the changing radio conditions. In order to improve the transmission from the base station data associated with the geographic position of the mobile station can be used. Thus, in GB-2271486 a communication system is disclosed, wherein a base station communicates with a number of mobile communication devices and is coupled to a central controller for relaying messages to the controller and for receiving and relaying control information from the controller. A number of mobile stations are provided with a GPS (Global position system) receiver in order to receive information from a GPS relating each mobile communication device to a geographic position (x, y, z). A transceiver transmits messages to the base station and receives control information from the base station. A transmitted message includes information relating to the geographic position (x, y, z) and the controller administers, through control of a base station, control of the communication system in response to geographic position information transmitted by the mobile communication devices. In the patent application GB-2271486 a method for dividing the coverage area into overlapping and non-overlapping areas and assigning different channels depending on the position of the mobile is disclosed. Signal strength decides the partitioning of the area not using any filtering of the position information. The deficiency is that said data are of insufficient quality as said data are registered for each measurement point.

ISDOCID: <WO_____0030384A1_I_>

WO-9801768 discloses a facility to make timing measurements between base stations and a mobile station in order to indicate the distance of the mobile station from at least one of the base stations. The distance indications in these systems will often be processed to produce an ambiguous indication of the position of the mobile station, and WO-9810768 deals with resolving position ambiguities using several techniques such as signal averaging, forming a signal contour map, making Doppler measurements, obtaining traffic flow information, and processing historical position data. In a second aspect the combination of two or more of the ambiguity resolution techniques can be achieved by multi-sensor fusion, probabilistic approaches, nearest neighbour and Kalman filter techniques that allow the integration of multiple sources of information over time. The preferred technique for integrating and evaluating the sequence of timing measurements is using the Kalman filter combined with probabilistic techniques to weight each of the measured events. The most likely of the sequences is chosen as indicating the true position of the mobile station. A spin-off of the technique is the ability to automatically derive signal strength contour maps. These maps can be used to improve the hand-off performance of the cellular network and for the purposes of network planning and design. The signal strength maps are continually updated, and it is hence possible to have them compensated for seasonal changes, such as tree foliage, by changing multipath and signal occlusion and this enables an automatic adaptation to any changes in the mobile network configuration. A single signal strength measurement may be susceptible to various fading influences, and a method using a single signal strength may use various signal averaging techniques to obtain a signal strength

measure more indicative of the location of the mobile station. A signal strength contour map may be generated, and this map may also be used to resolve ambiguities. A system in which the method described in WO-9801768 is carried out may continuously integrate information from many sources to keep the information up to date and to compensate for the time-of-day, day to day and seasonal variations. The deficiency with the solution described in WO-9801768 is that it only deals with finding the exact location of the mobile station.

WO-9427398 discloses a method to determine the location of a mobile station using GPS, LORAN (LOcation Radio Based Navigation), triangulation or other position determining systems. Information on the geographic location, shape and size of each cell is stored in a look-up table. The position of the mobile station is constantly updated, and call management decisions, such as hand-off, can be made based on the location of the mobile station. The MTSO (Mobile Telecommunication Switching Office) has a look-up table in its data storage facilities which is used for comparing positional data from the mobile stations to data associated with the cell site coverage areas. Based on a look-up in this table, the MTSO can select the cell site, which is the most appropriate to a call. The deficiency of the disclosure of the application WO-9427398 is that the data in the database is not regularly updated.

JP-06350516 discloses a method for determining positions of mobile stations using the GPS. A receiver receives electromagnetic waves from a measuring object of the mobile station. A statistical processor processes the amplitude of the electromagnetic waves. A controller stores the statis-

tically processed data, based on the position information of the navigation system controller. The method according to JP-06350516 is used to determine base stations in hand-off. The data are only statically processed, and then time is not considered, which is not satisfactory in order to provide an accurate description of the radio conditions of an area around the mobile station.

SUMMARY OF THE INVENTION

The methods disclosed in the cited documents GB-2271486, GB-2313742, WO-9801768, WO-9427398, JP-06350516 deal with the position of the mobile station. None of these cited documents deals with processing incoming data related to mobile stations in a radio telecommunication system in such a way that it is possible to extract useful information concerning the radio conditions around a considered mobile station.

The deficiency is that the information is not filtered using coefficients considering area and time, and therefore the information can not be used in algorithms, which may improve the performance of the network. The term "filter" is herein defined as the mathematical process by means of which the data concerning the mobile station, its position, signal quality, and other information, are processed over area and time. The term "filtering" is herein defined as using the filter by means of which the incoming data are processed. The term "smoothing filter" is herein defined as a filter, which smoothes data concerning the radio conditions, i.e. decreasing variance of data. The term "active set" is herein defined as the set of base stations, which communicate with a considered mobile station.

BNSDOCID: <WO_____0030384A1_I_>

One object of the present invention is thus to process the information concerning the location of the mobile station by means of a filter in order to create a map of signal quality versus location. This map may be used to more accurately predict radio conditions in each zone and hence change the performance of the radio network algorithms.

A further object of the invention is to determine if a base station belongs to the active set, e.g. for soft hand-off in a CDMA system or macro diversity in general.

Another object of the invention is to force a mobile station to make hand-off earlier than scheduled due to some expected change, for example before entering a tunnel, using said processed information.

The present invention is intended to solve the problem associated with controlling the transmission in communication with a mobile station using information on the geographic position and the radio environment of the mobile station. It is made by processing the information, e.g. by means of a filter in order to smooth information, which is generally measured for specific, localised geographic positions, not for an area. This information is processed to be valid for a region according to a probability function. Then slowly varying position based information of the radio conditions is obtained which can then be used to enhance the performance of the existing radio network algorithms.

The present invention thus provides methods for processing radio condition information related to the location of the mobile station in order to improve existing radio network

algorithms, e.g. algorithms for hand-off, cell selection or creating dynamic cell sizes. The initial choice of communication channel and output power could also be improved by this location dependent information.

An advantage of the invention is that it enables, using said processed information, the choice of a channel with a minimum of interference.

An other advantage of the invention is that it enables, using said processed information, the choice of power setting, in order to optimise the use of energy, i.e. to use appropriate amount of energy.

A further advantage of the invention is that it enables, using said processed information, the choice of an appropriate base station, e.g. the base station in a hierarchical cell structure providing the best quality versus power consumption.

The invention creates opportunities to enhance the performance of existing radio network algorithms by predicting the radio conditions within a specified area. It also reduces the need for highly accurate position measurements when applying the position related information in network functions since the filtering over the area smoothes the measurements made on several points in the database.

The invention also creates possibilities to decrease the size and identify the areas where certain events, such as dropped calls or failed hand-offs, often occur. This could be used to make it possible to start countermeasures against poor

planning or configuration of the communication system, e.g. size and location of the cells.

The system, method and apparatus according to the invention is characterised by the features set forth in the characterising clause of the independent claims 1, 20 and 40 and their associated dependent claims.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail by way of example with reference to preferred non-limiting embodiments thereof and also with reference to the accompanying drawings; wherein

Figure 1 is a flowchart illustration of the operational steps of a system according to the invention.

Figure 2a, 2b illustrate components and processing steps of a system for communication with a mobile station.

Figure 3 is a flow chart of the steps used in handling a database according to the invention.

Figure 4 shows another embodiment of the invention.

Figure 5 shows yet another embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 shows a flow chart illustrating the functional steps of one embodiment of the invention.

In a first block 10, data concerning the position of a considered mobile station are collected, for example by means of triangulation or GPS, events such as lost connection or hand-off failure at the registered position and signal quality, signal strength and the time when said events occurred. In the case of a lost connection, the information concerning the position of the mobile station may be collected at the time when the connection is lost. In the next block 25, said data are sent from the mobile station to a base station, and the base station then measures the signal quality and the signal strength when receiving the data and relates the measured information to the position reported in the received data. Also, in this block 25, events such as lost connections are recorded and also this information is related to the reported position or the last known position of the considered mobile station. Thereupon, in a block 30, the data now collected relating to the considered mobile station are provided to a processing unit where data from many mobile stations are processed. Next, in a block 40, the data are filtered in the processing unit in such a way that

the information now collected concerning the considered mobile station, including its position, is analysed with respect to earlier collected and processed data concerning an area of a predetermined size on the map around the mobile station, in order to create logical zones, the zones being determined in such a way that the radio conditions in each zone are similar or can at least be considered to be substantially constant. In the next block 50, the now collected data are classified according to predefined criteria, such as an interval for signal strength or a threshold value for the bit rate, and grouped together in order to create a map divided into said logical zones, where each logical zone is supposed to be a part of, and often much smaller than, a cell. Each logical zone has a classification, which relates to the radio conditions in said zone. In block 55, these data are stored in a database, which is updated from time to time, depending on the system. As the number of measurements related to every position increases, the knowledge of the radio condition of the respective position increases. At peak hours, when the system is very busy and in high demand of optimisation, the database may be frequently updated. At night, when the load is low, predefined parameters might be used. Also, old maps could be saved for later use. For example, it is possible to reuse, in e.g. December, the winter map from the previous year. The blocks 50 and 55 may be processed in the reverse order. Thereafter the processed data are again processed, together with new data in order to improve the quality of the map, see block 40. In block 60, an algorithm uses the information in the database in order to control the admission of a mobile station to the network, the choice of an adequate base station, the choice of an adequate channel, and the required

\SDOCID: <WO_____0030384A1_I_>

amount of power. As the "ground speed" of the mobile station is limited, i.e. the mobile station is not supposed to travel faster than a car, the method as described herein offers a possibility to predict the radio conditions in the immediate future. The information provided in the database is used for each call.

Fig. 2a shows an example of how the filtering and the storing of the data are performed. At 210, the measurement report is sent from the mobile station to the base station, wherein the measurement report contains at least one quality measure and information of the position. The quality measure is filtered over the area by a smoothing filter in step 220. In this example, a step 230 for processing through a filter having isometric dependency is used where,

$$Q(x,y,z) = Q' \frac{1}{1+d} \quad \text{and}$$

$$d = \left|(x,y,z) - (x',y',z')\right|,$$

where Q is an estimated value,

Q´ is an input value of a quality measure, e.g. signal strength,

d is the distance from the point (x´, y´, z´) where the input value Q´ is measured and the running coordinates (x, y, z),

x, y, z are the running coordinates of a point in the area,

x´, y´, z´ are the coordinates of the point for which the input value Q´ is measured.

BNSDOCID: <WO_____0030384A1_I_>

The filter does not have to be isometric i.e. to have an equal dependency in all directions, since perhaps the resolution in the z- direction needs to be higher than for the x- and y- directions. The map, or the new function Q(x,y,z) that we obtain from the smoothing filter at the point of measurement n at the time t, is called $\delta(t)$ and is used to update the old quality map $M(t-1)$. Said quality map $M(t-1)$ may be stored in a buffer coupled to the updating filter. The updating filter in step 230 can be an IIR filter (Infinite Impulse Response) or a FIR filter (Finite Impulse Response), but in this example it is an IIR filter of the first order where

$$M(t) = \alpha \cdot \delta(t) + (1-\alpha) \cdot M(t-1),$$

where α is filter coefficient.

In step 240, a time varying map is kept for each quality measure that is being used in the classifying step 260. These maps are classified in step 260 according to some criteria, e. g., that the signal strength is between -95 dBm and -105 dBm or the BER (Bit Error Rate) is larger than 10^{-6}. Identifying the areas where a combination of these classifications is considered to be constant is called grouping the data, which is performed in step 270. The final map, that results from the grouping step 270, is stored, in step 280, in a database, for later use.

The usage of the database is shown in the lowest part of fig. 2b. In step 290, a measurement report arrives to the system and the position information is extracted. The position information is used to, from the map in the database, extract information of the radio conditions in the vicinity of the

considered mobile station. The information of the radio conditions is then used in step 295 to enhance the performance of the radio network algorithms, such as hand-off, power setting or channel selection. The output from the radio network algorithms are then used in step 297 by the radio network controller to control the system.

In another embodiment, the updated value from step 230 may be buffered in a database, and several maps may be buffered for each Q-value. However, this embodiment requires another algorithm for extracting the information of the radio conditions to be used in the radio network algorithms.

Figure 3 depicts a flowchart illustrating an example of a method for the usage of the database.

In block 310, the area covered by this database is divided into smaller parts of the area, called zones, where the radio conditions in some term(s) are considered to be similar or can at least be considered to be substantially constant. In block 320, the zone in which the mobile station is situated is selected, according to the position report. In block 330, within each of these zones, the radio conditions can be predicted more accurately and hence the performance of the radio network algorithms can be enhanced, these algorithms can for example be:

- to determine if a base station belongs to the active set, e.g. for soft hand-off in a CDMA system (Code Division Multiple Access), or macro diversity in general,

- to force a mobile station to make hand-off earlier than scheduled due to some expected change, for example before entering a tunnel,

- to choose channel depending on in which zone the mobile station is located,

- to choose power setting, in order to optimise the use of energy, e.g. to use appropriate amount of energy,

- to choose an appropriate base station, e.g. the base station in a hierarchical cell structure providing the best quality versus power consumption,

- to use said processed information to provide dynamic cell size.

Figure 4 depicts a mobile station M in a cell C under control of a base station BS. The cell C is divided into a number of zones, z1-z7, where at least one radio condition is considered to be similar or can at least be considered to be substantially constant (e.g. signal strength on the uplink or power requirement on the down link or wherein a predetermined choice of channel is preferred) from a mobile station in a zone to the base station BS. For example, zone z1 provides the best signal quality as it is situated next to the base station BS, and the signal quality might be quite bad in zone z3 as a hill is situated between the base station BS and zone z3. The base station observes that the mobile station is about to leave a zone z6, which requires a certain radio condition (e.g. a relatively high power on the down link), and enter a zone z7, which require another radio condition (e.g. a relatively low power on the down link). The base station BS can thus adapt the transmission on the down link (and e.g. save energy) or tune to a more adequate channel.

Figure 5 depicts a mobile station M travelling in the direction of a tunnel. The mobile station M is under control of a base station BS1. BS1 does not reach the tunnel. A base station BS2 controls the area in the tunnel. The database informs BS1 that the mobile station M1 soon will enter the tunnel and thus loose contact with BS1. BS1 performs a hand-off in advance to BS2. Thus the mobile station M1 can continue to communicate.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

1. A radio telecommunication system comprising at least one mobile station, a database and at least one base station, which has transmitting means connected to the database, a set of radio conditions being measured and related to a position of the at least one mobile station, **characterised** by comprising

- position determining means for determining a position of the mobile station,
- measuring means for measuring radio conditions in communication between the base station and the mobile station,
- processing means connected to the position determining means and the measuring means for mathematically processing measured data concerning the radio conditions and measured data on the position of the mobile station comprising analysing the data of radio conditions and position with respect to earlier processed and stored data concerning radio conditions related to positions of a mobile station in an area around the determined position of the mobile station,
- storing means connected to the processing means for storing processed data in the database, and
- said transmitting means being arranged to control transmission to the mobile station in accordance with data stored in the database relating to the radio conditions associated with the determined position of the mobile station.

2. System according to claim 1, **characterised** in that the base stations comprise means for collecting information

NSDOCID: <WO_____0030384A1_I_>

on the uplink and relating said information to the position of the mobile station.

3. System according to claim 1 or 2, **characterised** by comprising means for collecting said data and positional information at the time when the connection is lost.

4. System according to any of claims 1-3, **characterised** by comprising means for performing an algorithm which uses said processed data in order to change the performance of the radio telecommunication network.

5. System according to claim 4, **characterised** by comprising means which in the processing step smoothes information over the area and then weights said information with earlier collected and processed data.

6. System according to any of claims 1 - 5, **characterised** in that said processing means comprise (s) an IIR filter.

7. System according to any of claims 1 - 5, **characterised** in that said processing means comprise (s) an IIR filter $M(t)$ of the first order where

$M(t) = \alpha \cdot \delta(t) + (1-\alpha) \cdot M(t-1)$, where

M is the processing in each point of the map, varying with the time,

t is the time, and

$\delta(t)$ is a measured value, which is processed over the area at the time t.

8. System according to any of claims 1 - 5, **characterised** in that said processing means comprise (s) a FIR-filter.

9. System according to any of claims 1 - 8, **characterised** in that said processing means comprise (s) a filter having isometric dependency, where,

$$Q(x,y,z) = Q' \frac{1}{1+d}, \text{ and}$$

$$d = \left|(x,y,z) - (x',y',z')\right|,$$

where Q is an estimated value,

Q´ is an input value of a quality measure,

d is the distance from the point (x´, y´, z´) where the input value Q´ is measured and the running coordinates (x, y, z),

x, y, z are the running coordinates of a point in the area, and

x´, y´, z´ are the coordinates of the point for which the input value Q´ is measured.

10. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to determine if a base station belongs to an active set.

11. System according to claim 10, **characterised** in that the active set is used for performing soft hand-off in a CDMA system.

NSDOCID: <WO_____0030384A1_I_>

12. System according to claim 10, **characterised** in that the active set is used for performing macro diversity.

13. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to force a mobile station to make hand-off earlier than scheduled due to some expected change.

14. System according to any of claims 1 - 9, **characterised** by comprising using the processed information in an algorithm to force a mobile station to make hand-off earlier than scheduled due to some expected geographic change.

15. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to choose channel depending on the zone in which the mobile station is located.

16. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to choose power setting.

17. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to choose an appropriate base station.

18. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to determine size and location of the cells.

19. System according to any of claims 1 - 9, **characterised** by comprising means using the processed information in an algorithm to assist in the placement of new base stations.

BNSDOCID: <WO_____0030384A1_I_>

20. A method for filtering data, collected from connections in a radio telecommunication system, which includes a number of mobile stations and at least one base station, wherein radio conditions being measured and the information is related to a current reported position of a mobile station, **characterised** by the steps of:

- processing incoming data by a filter in such a way that the information related to a mobile station and its position is analysed with respect to earlier collected and processed data concerning an area of a predetermined size on the map around the mobile station,
- classifying and grouping said data to create a map divided into zones, to give each zone a classification, which indicates the radio conditions in the zone, so that the radio conditions are uniform in each zone,
- storing the classified data in a database, and updating the data stored in the database from time to time,

21. A method according to claim 20, **characterised** in that the base stations collect information on the uplink and that said information is related to the position of the mobile station.

22. A method according to claim 20 or 21, **characterised** in that the information related to the position of the mobile station is obtained through triangulation or GPS.

23. A method according to any of claim 20 - 22, **characterised** in that the data and the information concerning

the position of the mobile station are collected at the time when the connection is lost.

24. A method according to any of claims 20 - 23, **characterised** in further comprising the step of

- using said classified data in an algorithm in order to change the performance of the radio telecommunication network.

25. A method according to claim 24, **characterised** in that in the processing step the information is smoothed over the area and then weighted with the earlier collected and processed data.

26. A method according to any of claims 20 - 25, **characterised** in that the filter is an IIR filter.

27. A method according to any of claims 20 - 25, **characterised** in that the filter is an IIR filter *M(n)* of the first order, where

$M(t) = \alpha \cdot \delta(t) + (1-\alpha) \cdot M(t-1)$, where

M is the filtering in each point of the map, varying with the time,

t is the time

$\delta(t)$ is the area filtered measured value at the time t.

28. A method according to any of claims 20 - 25, **characterised** in that the filter is a FIR-filter.

29. A method according to any of claims 20 - 28, **characterised** in that the filter is a filter having isometric dependency, where

$$Q(x,y,z) = Q' \frac{1}{1+d}, \text{ and}$$

$$d = \left|(x,y,z) - (x',y',z')\right|,$$

where Q is an estimated value,

Q´ is an input value of a quality measure,

d is the distance from the point (x´, y´, z´) where the input value Q´ is measured and the running coordinates (x, y, z),

x, y, z are the running coordinates of a point in the area, and

x´, y´, z´ are the coordinates of the point for which the input value Q´ is measured.

30. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to determine if a base station belongs to an active set.

31. A method according to claim 30, characterised in that the active set is used for performing soft hand-off in a CDMA system.

32. A method according to claim 30, characterised in that the active set is used for performing macro diversity.

33. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm

to force a mobile station to make hand-off earlier than scheduled due to some expected change.

34. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to force a mobile station to make hand-off earlier than scheduled due to some expected change, wherein the change is geographic.

35. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to choose channel depending on the zone in which the mobile station is located.

36. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to choose power setting.

37. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to choose an appropriate base station.

38. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to provide dynamic cell size.

39. A method according to any of claims 20 - 29, **characterised** in that the filtered information is used in an algorithm to assist in the placement of new base stations.

40. Apparatus for filtering data, collected from connections in a radio telecommunication system including a number of mobile stations and at least one base station,

wherein the radio conditions being measured and the information is related to the current reported position, **characterised** in that the apparatus comprises;

- means for processing incoming data by a filter in such a way that the information related to a mobile station and its position is analysed with respect to earlier collected data concerning an area of a predetermined size on the map around the mobile station,
- means for classifying and grouping said data together in order to create a map divided into zones, to give each zone a classification, which indicates the radio conditions in the zone, wherein the radio conditions are uniform in each zone,
- means for storing said classified data in a database, which is updated from time to time.

41. Apparatus according to claim 40, **characterised** in that the base stations comprise means for collecting information on the uplink and relating said information to the position of the mobile station.

42. Apparatus according to claim 40 or 41, **characterised** by comprising means for collecting said data and positional information at the time when the connection is lost.

43. Apparatus according to any of claims 40 - 42, **characterised** by comprising means for performing an algorithm which uses said classified data in order to change the performance of the radio telecommunication network.

\SDOCID: <WO_____0030384A1_I_>

44. Apparatus according to claim 43, **characterised** by comprising means which in the processing step smoothes information over the area and then weights said information with earlier collected and processed data.

45. Apparatus according to any of claims 40 - 44, **characterised** in that the filter is an IIR filter.

46. Apparatus according to any of the claims 40 - 44, **characterised** in that the filter is an IIR filter $M(t)$ of the first order where

$M(t) = \alpha \cdot \delta(t) + (1-\alpha) \cdot M(t-1)$, where

M is the filtering in each point of the map, varying with the time,

t is the time, and

$\delta(t)$ is a measured value, which is filtered over the area at the time t.

47. Apparatus according to any of claims 40 - 44, **characterised** in that the filter is a FIR-filter.

48. Apparatus according to any of the claims 40 - 47, **characterised** in that the filter is a filter having isometric dependency, where,

$Q(x,y,z) = Q' \frac{1}{1+d}$, and

$d = |(x,y,z) - (x',y',z')|$,

BNSDOCID: <WO_____0030384A1_I_>

where Q is an estimated value,

Q´ is an input value of a quality measure,

d is the distance from the point (x´, y´, z´) where the input value Q´ is measured and the running coordinates (x, y, z),

x, y, z are the running coordinates of a point in the area, and

x´, y´, z´ are the coordinates of the point for which the input value Q´ is measured.

49. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to determine if a base station belongs to an active set.

50. Apparatus according to claim 49, **characterised** in that the active set is used for soft hand-off in a CDMA system.

51. Apparatus according to claim 49, **characterised** in that the active set is used for performing macro diversity.

52. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to force a mobile station to make hand-off earlier than scheduled due to some expected change.

53. Apparatus according to any of claims 40 - 48, **characterised** by comprising using the filtered information in an algorithm to force a mobile station to make hand-off earlier than scheduled due to some expected geographic change.

54. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to choose channel depending on the zone in which the mobile station is located.

55. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to choose power setting.

56. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to choose an appropriate base station.

57. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to determine size and location of the cells.

58. Apparatus according to any of claims 40 - 48, **characterised** by comprising means using the filtered information in an algorithm to assist in the placement of new base stations.

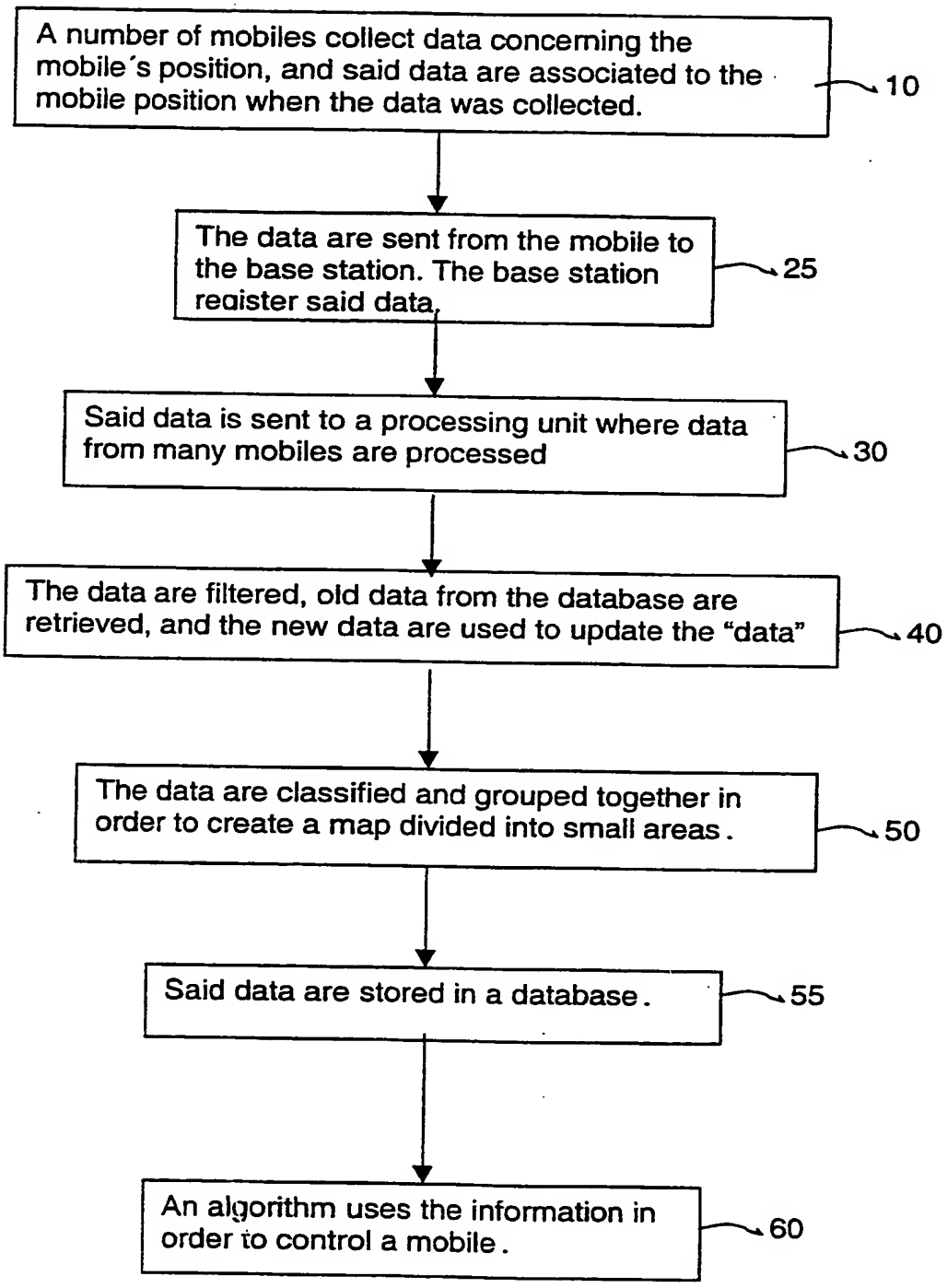

A number of mobiles collect data concerning the mobile´s position, and said data are associated to the mobile position when the data was collected.
10
The data are sent from the mobile to the base station. The base station register said data.
25
Said data is sent to a processing unit where data from many mobiles are processed
30
The data are filtered, old data from the database are retrieved, and the new data are used to update the "data"
40
The data are classified and grouped together in order to create a map divided into small areas.
50
Said data are stored in a database.
55
An algorithm uses the information in order to control a mobile.
60

Fig. 1

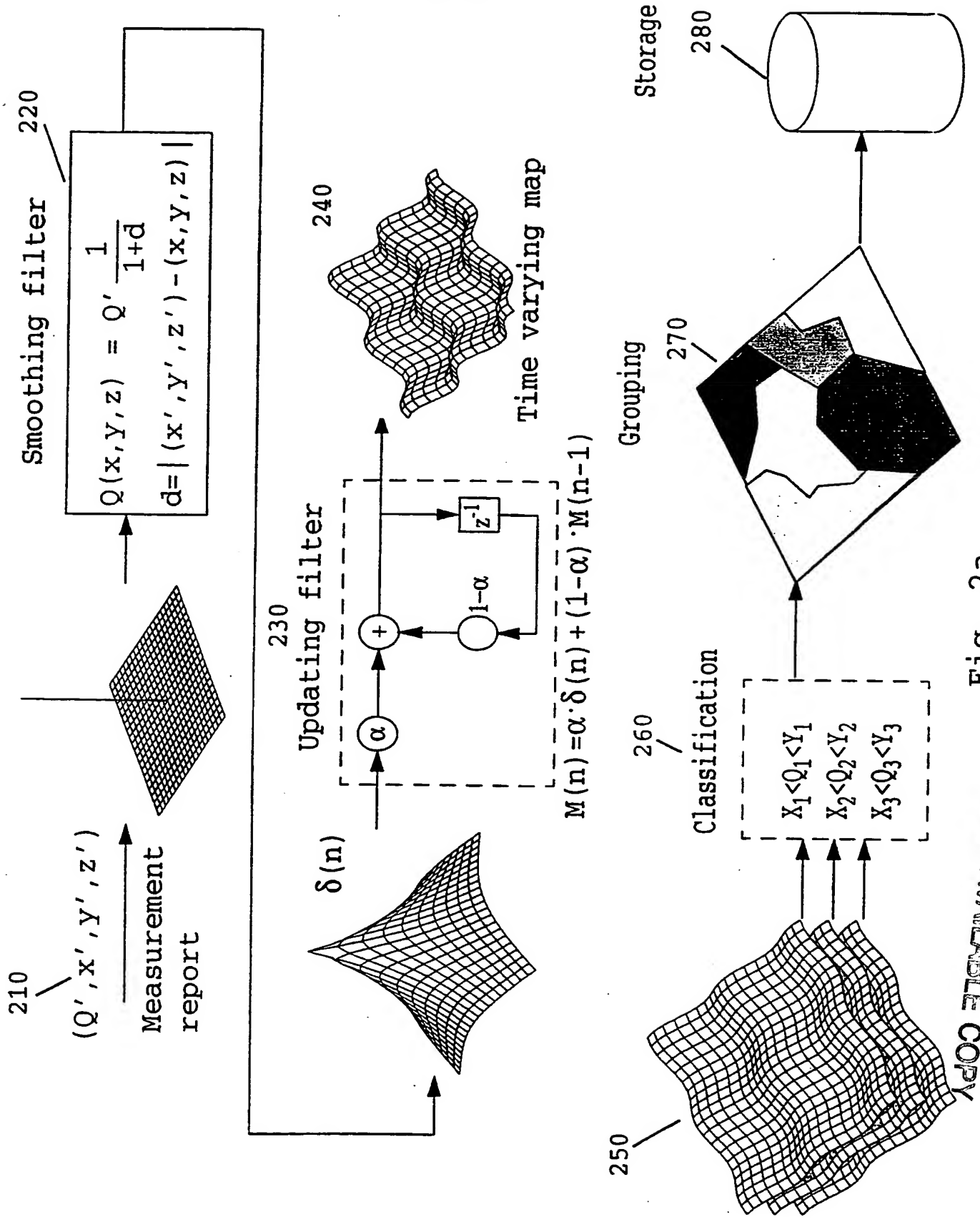


Fig. 2a

BEST AVAILABLE COPY

BNSDOCID: <WO_____0030384A1_I_>

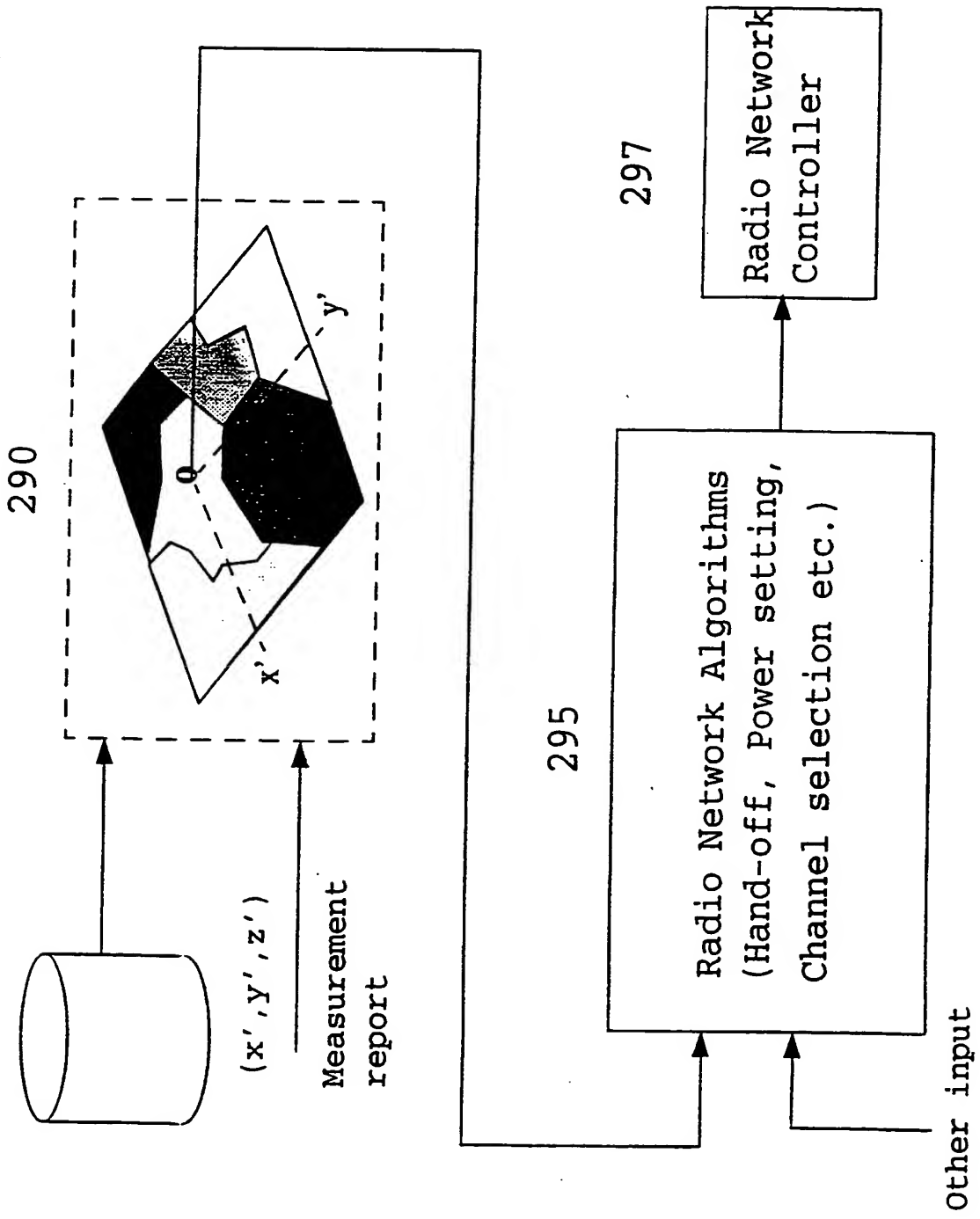


Fig. 2b

SDOCID: <WO_____0030384A1_I_>

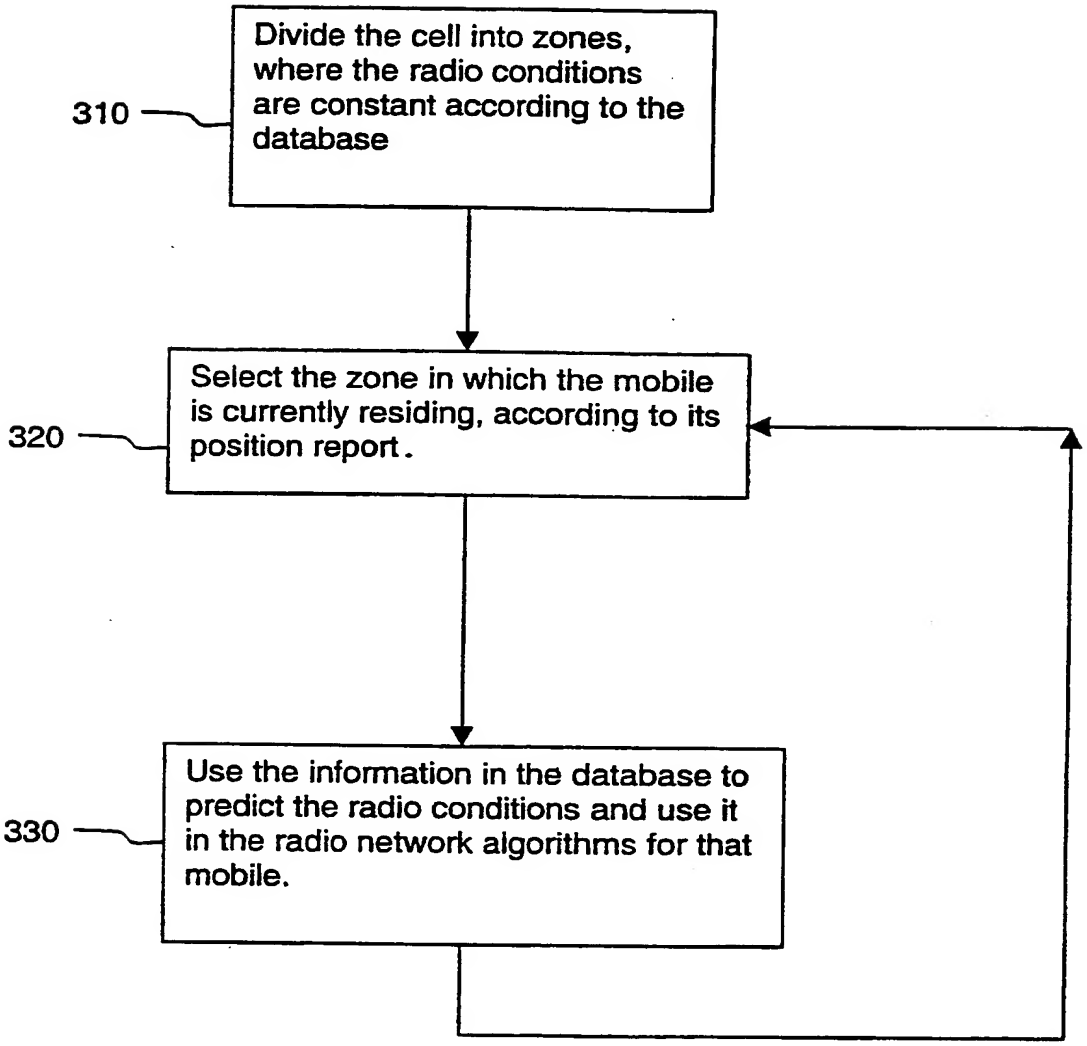

Divide the cell into zones, where the radio conditions are constant according to the database
310
Select the zone in which the mobile is currently residing, according to its position report.
320
Use the information in the database to predict the radio conditions and use it in the radio network algorithms for that mobile.
330

Fig. 3

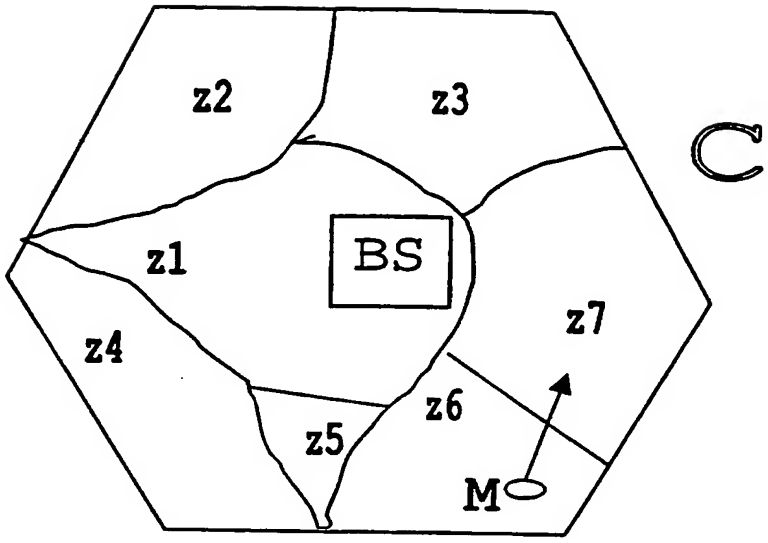


Fig. 4

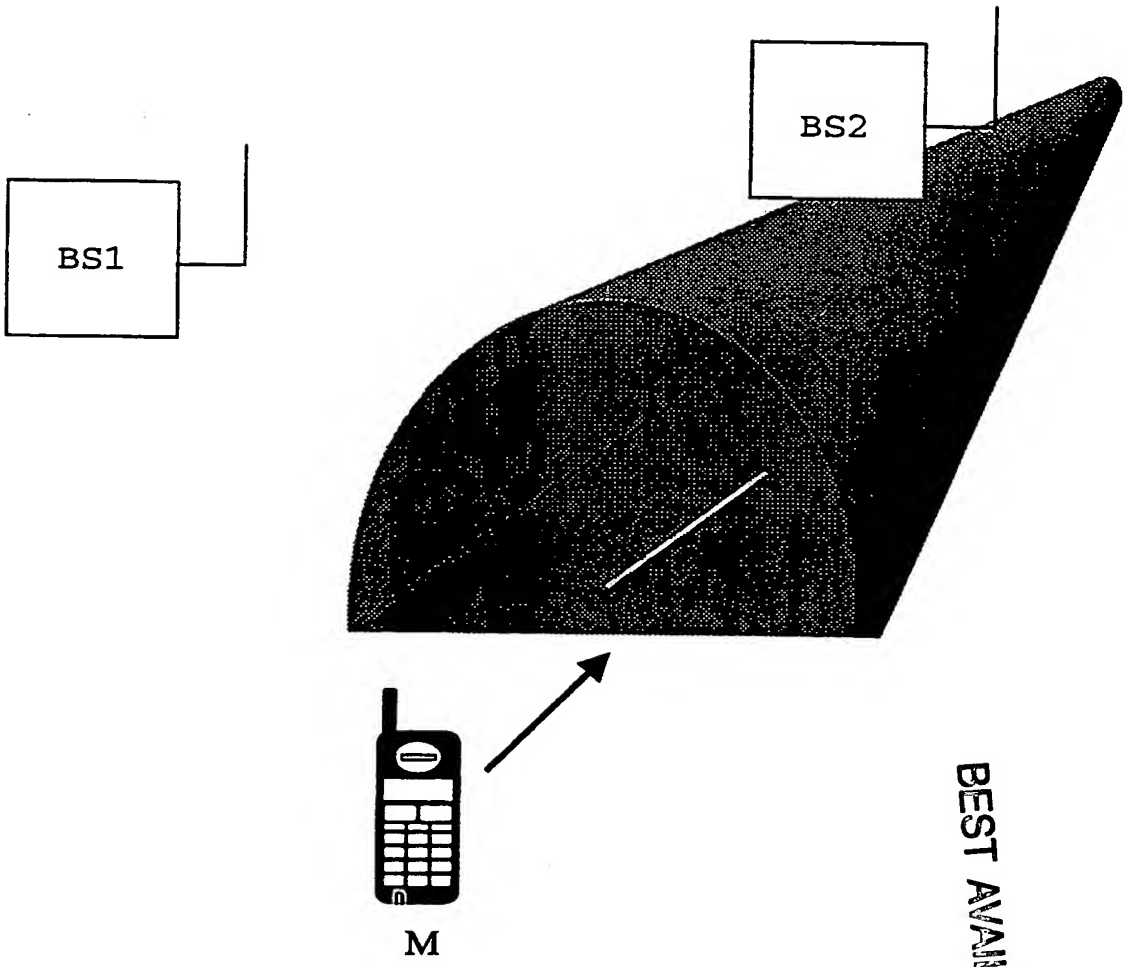


Fig. 5

BEST AVAILABLE COPY

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/01746

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 48194 A (MOTOROLA INC.) 18 December 1997 (1997-12-18) page 3, line 28 -page 6, line 26 -/—	1,2,4, 13-15, 20-22, 24, 33-35, 40,41, 43,52-54

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 January 2000	28/01/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Behringer, L.V.

Form PCT/ISA/210 (second sheet) (July 1992)

ISDOCID: <WO_____0030384A1_I_>

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/01746

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JUNIUS M: ""INTELLIGENTES" RADIO RESOURCE MANAGEMENT. MUSTERERKENNUNG MIT GSM -FUNKMESSDATEN UND ANWENDUNG" ITG-FACHBERICHTE, vol. 124, 27 September 1993 (1993-09-27), pages 487-501, XP002006361 ISSN: 0932-6022	1,2,4,5, 20,21, 24,25, 40,41, 43,44
A	page 499, line 17 -page 500, line 11	13,14, 33,34, 52,53
X	EP 0 871 339 A (DETEMOBIL DEUTSCHE TELEKOM MOBILNET GMBH) 14 October 1998 (1998-10-14)	20,21, 23,40-42
A	the whole document	1
A	GB 2 271 486 A (MOTOROLA LTD) 13 April 1994 (1994-04-13) cited in the application	1,2,4, 13,14, 16, 20-22, 24,34, 36,40, 41,43, 52,53,55
	page 13, line 1 -page 15, line 13	
A	EP 0 454 638 A (TELEFONAKTIEBOLAGET L M ERICSSON) 30 October 1991 (1991-10-30)	1,2,4, 13,14, 17,20, 21,33, 34,37, 40,41, 52,53,56
	column 2, line 28 -column 4, line 57 column 5, line 29 - line 46	

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

BNSDOCID: <WO_____0030384A1_I_>

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ational Application No
PCT/SE 99/01746

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9748194 A	18-12-1997	US 5926761 A	20-07-1999
		BR 9702317 A	09-03-1999
		CA 2228899 A	18-12-1997
		CN 1195435 A	07-10-1998
		EP 0843919 A	27-05-1998
		JP 11510992 T	21-09-1999
EP 0871339 A	14-10-1998	DE 19714743 A	15-10-1998
GB 2271486 A	13-04-1994	NONE	
EP 0454638 A	30-10-1991	SE 466081 B	09-12-1991
		AU 636742 B	06-05-1993
		AU 7562991 A	11-11-1991
		CA 2057068 A	27-10-1991
		CN 1056213 A,B	13-11-1991
		DE 69102486 D	21-07-1994
		DE 69102486 T	20-10-1994
		ES 2055578 T	16-08-1994
		HK 115294 A	27-10-1994
		JP 4507179 T	10-12-1992
		SE 9001497 A	27-10-1991
		WO 9116772 A	31-10-1991
		US 5293643 A	08-03-1994

NSDOCID: <WO_____0030384A1_I_>